





- Microcontroller calculates the phase difference between them as well as power factor.
- According to the difference between measured power factor and desired power factor, microcontroller generates control signal and controls the excitation current of synchronous condenser.
- LCD module is connected to the PORT A of AVR microcontroller.
- The system power factor can be monitored by LCD.
- This process continues until the measured power factor equals the desired power factor.

**3.CONTROL SCHEME:**

Microcontroller ATmega32 has been used here. The pin diagram, features, internal architectures of microcontroller are available from standard datasheet of ATmega32. The control system is done by the following steps:

**3.1 Algorithm:**

An Algorithm is developed to make ATmega32 read the input and respond accordingly. An algorithm of the control scheme is shown in Figure 5

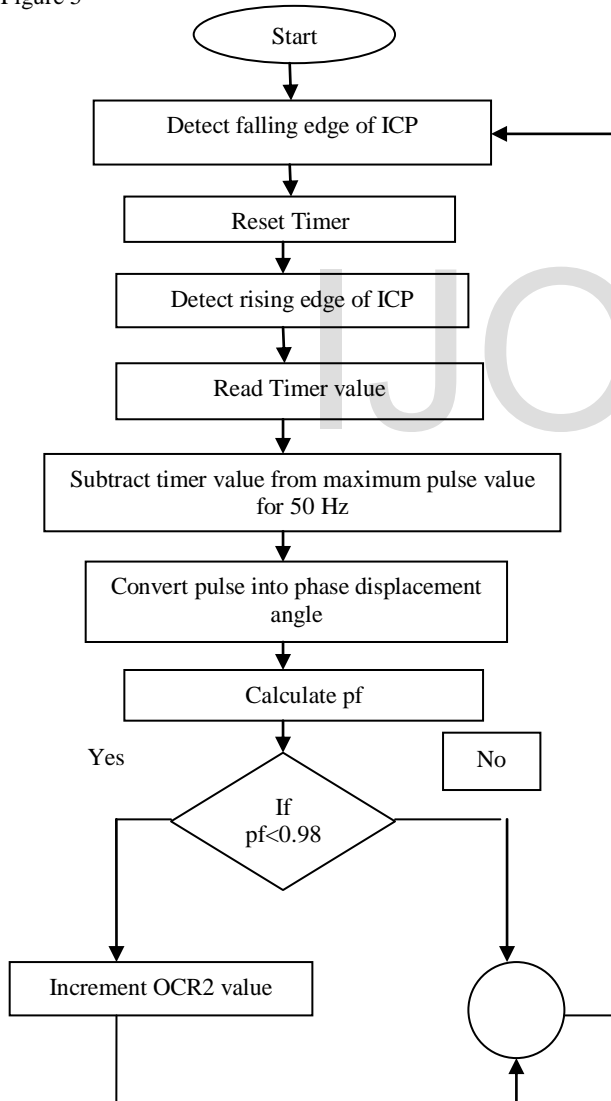


Figure 2: Program Algorithm

**3.2 Comparison of power factor and generation of control signal:**

Power factor of the system is calculated continuously by using an infinite loop and it is compared to desired power factor. After comparison necessary control signal is generated at the output port of microcontroller. The timer value increases to a certain limit. It looks like a ramp signal. There is a preset value of OCR1. It continuously compares timer value and OCR1 value and gives corresponding pulse width modulation. If power factor is less than the desired value then OCR1 value is changed and pulse width is also changed according to the difference between actual power factor and desired power factor.

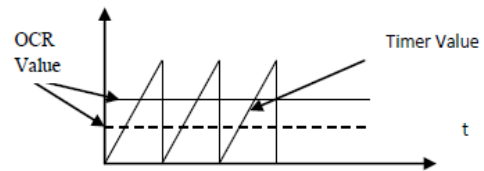


Figure 3-Comparison of timer value and preset OCR value

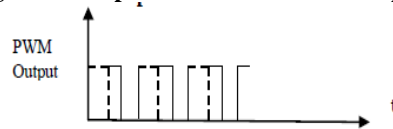


Figure 4- PWM output

**3.3 Power factor calculation:**

The 16-bit Timer/Counter unit allows accurate program execution timing, wave generation and signal timing measurement. The timer/counter incorporates an Input Capture unit that can capture external events and give them a time-stamp indicating time of occurrence. The external signal indicating an event, or multiple events, can be applied via the ICP pin of microcontroller

Let, CLK CPU = 4MHz  
 Pre-scale=8 CLK  
 timer = (4 MHz)/8 = 500 kHz  
 T timer = 1/(500 kHz) = 2µs  
 So, 2µs is needed to count pulse 1.  
 10ms is needed to count pulse = (10ms \* 1)/2µs = 5000

So, maximum pulse value=5000.

The input to the ICP pin is shown in Figure 2. Microcontroller detects its falling or rising edge as declared in the program. The timer value from one falling edge to next rising edge is taken first. Now this value is subtracted from the maximum pulse value [5]. This is the timer value of displacement between voltage and current.

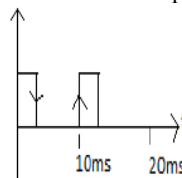


Figure 5: Output from XOR logic gate

Now, from the main signal we get,  
 10ms is equal to displacement = 3.1516 radian  
 1µs is equal to displacement = (3.1516/10000) radian = 0.00031516 radian  
 Now, pulse width, t = 2µs \* (5000-clock number)  
 Angle, α = 0.00031516 \* 2µs \* (5000-clock number) radian = 0.000628 \* (5000-clock number) radian

Power factor =  $\cos(\alpha)$ .

Here clock number is variable depending on the signal. Power factor can be easily calculated by this method.

### 3.4 Generation of control signal:

Power factor of the system is calculated continuously by using an infinite loop and it is compared to desired power factor. After comparison necessary control signal is generated at the output port of microcontroller. The timer value increases to a certain limit. It looks like a ramp signal. There is a preset value of OCR (Output Compare Register). It continuously compares timer value and OCR value and gives corresponding pulse width modulation. If power factor is less than the desired value then OCR value is changed and pulse width is also changed according to the difference between actual power factor and desired power factor.

## 4. Experimental Data:

| Serial no | Voltage(V)<br>volt | Current(I)<br>amp | Power(P)<br>watt | Power Factor( $\cos\phi$ )<br>( $P/V*I$ ) | Power Factor by microcontroller |
|-----------|--------------------|-------------------|------------------|---|---------------------------------|
| 1.        | 30                 | 0.6               | 13               | 0.73                                      | 0.72                            |
| 2.        | 30                 | 0.8               | 20               | 0.83                                      | 0.8                             |

### Error of power factor calculation:

1. Error =  $\{(0.73-0.72)/0.73\} * 100\% = 1.4\%$
2. Error =  $\{(0.83-0.8)/0.83\} * 100\% = 3.6\%$

## 5. Simulation & Result:

The experimental results can be divided into 5 sections. They are-

- Test the voltage and current level
- Detecting Zero crossing
- Finding time gap between voltage and current
- Power factor calculation and monitoring
- Generation of control signal for power factor correction.

The output signal of Exclusive-OR gate is now suitable to pass through the ICP pin of the microcontroller and the microcontroller calculates the power factor. LCD is interfaced with microcontroller and LCD displays the power factor.

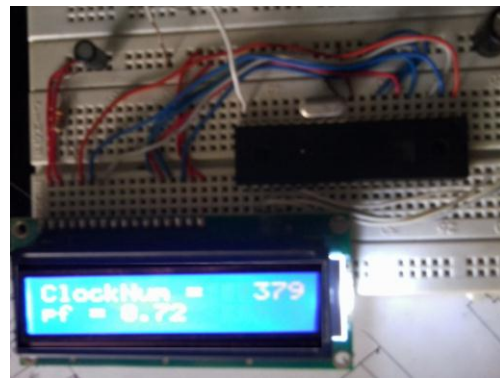


Figure 6: LCD Interfacing with microcontroller

The complete simulation circuit of this thesis work is shown in figure 6 and the power factor is measured continuously and required PWM signal is generated. The PWM signal generated from microcontroller is shown in figure 7.

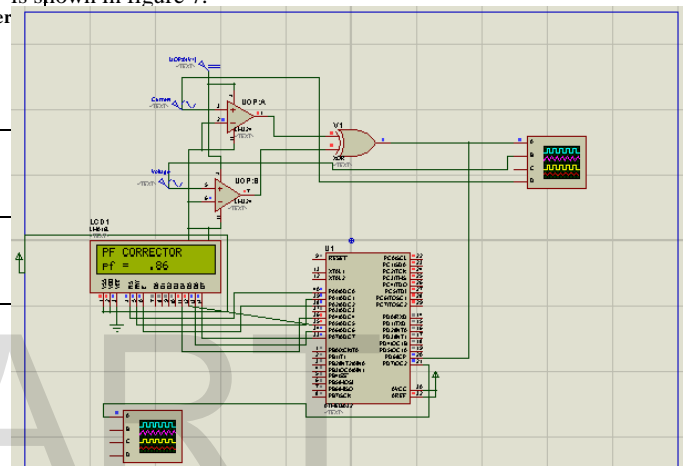


Figure 6: Simulation of PWM generation

By microcontroller, the control signal for power factor correction is the pulse width modulation (PWM) is generated which controls the gate pulse of thyristor[6]. Here, the thyristor controls the dc excitation of the synchronous condenser to improve the power factor.

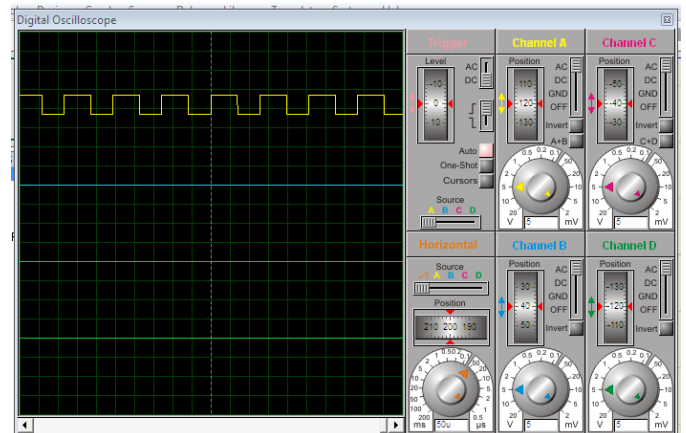


Figure 7: Simulation of generated PWM signal

## 6. Conclusion:

A well-organized technique for power factor calculation and correction is shown in this paper. Because of high cost of synchronous condenser the correction technique has been given theoretically but the PF calculation has been done practically. It is necessary to use synchronous condenser in high voltage system instead of capacitor bank because of long life of condenser. The power factor of the line is continuously monitored through the microcontroller. Here, required controlled signal is produced automatically for correction and it is a time saving technique. The technique is also very economical in comparison with capacitor bank. In order to improve power factor a variable speed synchronous condenser can be used in any high voltage transmission line and the speed of synchronous condenser can be controlled by microcontroller through the thyristor.

## 7. Future Work:

In order to control the excitation of the synchronous condenser with the power system is not a very easy task. By developing various easy ways for changing the speed of the condenser in order to change the excitation of the condenser. On the other hand, many other control devices such as PLC can be used for PF calculation and correction. The practical implementation of the correction scheme has

not been possible here. Proper calculation is necessary for implementation, because the excitation control is very sensitive.

## References:

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